CHAPTER 3

SAMPLING PROCEDURES

1. **DEFINITIONS**.

a. 8-hour Time-Weighted Average (TWA)/8-hour TWA-OEL. The time weighted average concentration for a normal 8-hour workday and a 40-hour work week which cannot be exceeded. It is accepted to be a concentration to which nearly all workers may be repeatedly exposed, day after day, without adverse effects.The average level of a stressor over a specified time period weighted for the length of time at each measured level. The measurement is usually a concentration of a chemical contaminant or a level of a physical agent (e.g., noise). The duration of the TWA must be specified. The most common industrial hygiene TWA duration is 8 hours which is the length of the most common work day. A TWA may be determined by a single sample (i.e., the averaging is done by the sampling device throughout the sampled period) or by mathematical combination of one or more consecutive samples.

b. Action Level (AL). One-half the 8-hour time-weighted average (TWA) value designated as the Navy Occupational Explosure Limit (OEL) unless a specific AL is established in an Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) adopted by the Navy (e.g., 60% of the OSHA standard for inorganic lead). The AL may initiate the implementation of specific actions, such as periodic monitoring, training or medical surveillance if specified by a NAVOSH or OSHA standard.

The necessity for an employee exposure action level is based on variations in the occupational environment (i.e., variations in the employee's daily exposures). As such, the employer should attempt to prove with 95% certainty that no employee's true daily average exposure (i.e., 8-hour TWA) exceeds the standard (References 3-1 and 3-2).

c. Ceiling (C)-OEL. A contaminant concentration that should not be exceeded during any part of the working exposure. If instantaneous monitoring is not feasible, samples are collected and assessed as a 15-minute time-weighted average exposure which should not exceed the Ceiling Value at any time during the working day.

d. Excursion Limit (EL)-OEL. Only one stressor, asbestos, currently has an EL. The EL for asbestos was set as a TWA over a 30-minute period which distinguishes it from an Short-Term Exposure Limit (STEL) which has a shorter averaging period.

e. Occupational Exposure Limit (OEL). Limits established to protect workers from workplace exposure to certain chemical substances or physical agents. OELs have many sources among them are legal standards (i.e., set by OSHA), professional association guidelines (e.g., ACGIH TLVs®, German MAKs), and government recommendations (i.e., NIOSH RELs) Based on the hierarchy establised in Chapter 8 of OPNAVINST 5100.23 Series, Navy OELs may be drawn from many of these sources.

f. Permissible Exposure Limit (PEL). A legally enforceable (in the U.S.) occupational exposure standard established by the federal Occupational Safety and Health Administration (OSHA) or by a state-run program accepted by OSHA. Most PELS are time-weighted average concentrations for a normal 8-hour workday and a 40-hour work week which shall not be exceeded. However, PELs may also be “Ceiling” values or “Excursion Limits.” PELs are accepted to be a concentration to which nearly all workers may be repeatedly exposed, day after day, over a working lifetime without adverse effects.

g. Short-Term Exposure Limit (STEL)-OEL. A 15-minute TWA exposure that should not be exceeded at any time during the workday. The STEL is not an independent exposure limit, but rather supplements the 8-hour TWA in cases where there are recognized acute effects from a substance whose toxic effects are primarily chronic.

2. **PURPOSE OF SAMPLING.** Sampling is conducted to quantify occupational exposures to workplace stressors. In most cases, when a qualitative positive determination is made, sampling is necessary to determine the extent of the exposure, adequacy of control methods in use, or additional controls required to eliminate or minimize the hazard. The exposure monitoring plan should be developed and implemented for those operations/processes needing further evaluation and those stressors for which periodic sampling is required by regulation or directive.

3. **TYPES OF AIR SAMPLES**. The following are the two major types of air samples used to determine the airborne concentration of contaminants:

a. Personal samples. For stressors having Navy OELs, for which a decision to sample has been made, personal exposure is determined by collecting breathing zone (BZ) samples. In rare instances, breathing zone sampling may not be feasible due to the lack of a personal sampling method or other considerations of the workplace environment. To obtain the sample, air is collected from within the breathing zone of the employee, a hemisphere forward of the shoulders and centered at the nose, with a radius of approximately 6 to 9 inches. Breathing zone samples may be collected in the following two ways:

(1) The sampling device is attached to the employee and worn continuously during the work shift or operation. This is the preferred method.

(2) The sampling device is held by a second individual within the breathing zone of the employee. For example, the industrial hygienist may use a detector tube hand pump to collect one or a series of grab samples from within the breathing zone of the employee.

NOTE: For stressors where there is no acceptable level of exposure, such as those regulated under 29 CFR 1910.1003, 1910.1004 and 1910.1006 through 1910.1016, personal sampling may not be necessary to document personnel exposures. These standards rely on work practice requirements and appropriate feasible control technology to eliminate exposures.

b. General area (GA) samples. The sampling equipment is placed in a fixed location in the work area. General area samples are not be used to evaluate employee exposure. They may be used to determine whether re-entry is warranted into a contaminated area, if there is potential contamination of adjacent work areas, or to verify the integrity of a negative pressure enclosure during asbestos ripout operations. They may not be used for Navy OEL compliance determinations except in the rare instances where no feasible personal sampling method exists.

4. **SAMPLE DURATION**. Sample duration may vary from a few seconds to 8 hours or more. The time period for sample collection depends on a variety of factors including: the samplng

and analytical method, the expected concentration of the contaminant being measured, the type of OEL to which the sample will be compared, the number of consecutive samples to be collected on a single employee during a single work shift, and whether the work shift is longer than 8 hours. Consider the following factors in determining the appropriate sample duration.

a. Sampling method. The sampling method is one factor in determining the duration of each sample. A single grab sample collected with short-term detector tubes is collected over a period of seconds to minutes. Low flow and high flow sampling pumps, combined with filter, impingers, and/or solid sorbent media, are used to collect longer duration samples generally 15 minutes to 8 hours. Direct reading instruments provide almost instantaneous or real-time results.

b. Contaminant concentration and analytical method. The concentration of a contaminant in the sampled air has a large effect on the sample duration. All other things being equal, the higher the concentration the shorter the duration of a single sample and vice versa. Minimum sampling times aim to collect enough mass of contaminant to be above the analytical method's limit of reliable quantification. Maximum sampling times aim not to collect too much mass of contaminant to avoid sorbent breakthrough or filter overloading. For example, charcoal tubes may need to be changed frequently to prevent breakthrough. The breakthrough time of a charcoal tube is a function of the air concentration of the contaminant being sampled, the sample flow rate, and the humidity of the environment being sampled. Breakthrough time is also a function of the type, amount, size and packing configuration of the charcoal in the tube and competition for sorbent sites by other contaminants present in the air. Similar limits on sampling time apply to filters and impingers to prevent overloading. Judgment should be exercised in changing sampling media of any type often enough to sample a sufficient volume of air to quantify the sample without the occurrence of breakthrough.

c. Type of OEL to which the sampling results will be compared. Samples collected for as close as possible to 100% of the time period for which the OEL is defined provide the best estimate of the time-weighted average employee exposure. Each type of OEL imposes different sample duration requirements as follows:

(1) Ceiling standard (C). Samples collected to determine compliance with ceiling limits are usually taken as a se-

ries of 15-minute samples during periods of maximum expected exposures. An exception would be if a real-time instrument (e.g., a datalogging dosimeter) were available to provide instantaneous and continuous measurements. According to reference 3-2, samples taken for comparison with ceiling limit OELs are best taken in a non-random fashion, during periods of maximum expected concentrations. A minimum of three measurements should be taken during each work shift sampled. The highest of all the measurement results is the best estimate of the employee's upper exposure for that shift.

(2) Short-term exposure limit (STEL). STEL samples should be taken over a 15 minute period. STEL samples should also be taken in a non-random fashion during periods of maximum expected concentration.

(3) 8-hour time weighted average OELs. Evaluate the potential for employee overexposure through observation and, if appropriate, collection of screening samples before any partial- or full-shift air sampling is conducted.

(a) Full-shift samples should be taken to evaluate TWA exposures whenever possible. However, due to the realities of field sampling (e.g., time lost due to placing and removing multiple sampling devices at the beginning and end of the work shift and lunch breaks), it is unusual that a sample or series of consecutive samples spans the entire work shift. In practical terms, a full-shift sample should omit no more than one hour of the full work shift (e.g., sample at least 7 hours of an 8-hour work shift or 11 hours of a 12-hour work shift).

(b) If full-shift sampling is not possible, it is essential to sample the entire duration of the task producing the exposure of interest. Every attempt should be made to sample the period of greatest exposure during the operation. Such exposure may occur during routine set-up, take-down, and end-of-shift clean-up operations. If an operation lasts less than a full shift, then sampling is to be conducted for the entire operation, or as long as personnel are potentially exposed to the contaminant (e.g., personnel may remain in a potentially contaminated work area after the operation ceases), whichever is longer.

(c) If the employee is leaving the general area of the work (e.g., going off-base or to an on-base fast food vendor) for lunch the sampler and media should be removed during the lunch period. If the employee will be eating lunch in a lunch room at the work site it is permissible to leave the sampler and media on the employee but any sampling pump should be turned off and the sample inlet should be capped. Be sure that the lunch break "on" and "off" times are recorded on the sampling data sheet and cap/seal and identify all cassettes/tubes if they are removed from the employee. One exception to removing and capping sampling devices during lunch are certain passive monitors which would require removal of the diffusion membrane to be capped. In such cases the monitor may be left in place during the lunch break with documentation to that effect or the monitor may be removed and placed in a sealed container at a clean air location. Shut-down and removal of the sampling train during lunch is preferred.

(d) If technology has not been developed to allow full-shift sampling for an 8-hour TWA, a series of "grab" or "spot" samples taken randomly throughout the work shift is acceptable. A sound statistical approach should be used to design the sampling strategy. See Reference 3-1 for a complete discussion.

d. Number of consecutive samples to be collected per employee. The number of consecutive samples that should be taken during a work shift depends on the desired error of measurement as discussed in references 3-2, 3-3, and 3-4 and in Chapter 4 of this manual. Two 4-hour consecutive samples provide more statistical power than one 8-hour sample when documenting the exposure for an 8-hour work shift. Up to a point, a larger number of shorter duration consecutive samples provides more statistical power. However, the need to collect sufficient mass of contaminant for accurate analysis limits how many consecutive samples may be used to cover a specific work shift.

e. Work shifts longer than 8 hours. In general, a single sample or multiple samples are to be taken to determine the initial 8 hours of exposure for comparison with the standard. This allows direct comparison to the 8-hour OEL. A separate sample is used to determine any additional exposure beyond the initial 8 hours.

5. CALCULATING THE TIME-WEIGHTED AVERAGE FROM THE SAMPLE RESULTS.

a. Unsampled work periods. To properly calculate an employee’s TWA exposure, professional judgment is necessary to decide what assumption should be made regarding the exposure during unsampled work periods. For example, if the work shift is 8 hours and sampling was conducted for 7 hours and 15 minutes, the industrial hygienist can either assume a zero exposure for the unsampled period or assume that exposure is equal to the TWA over the sampled period. If a zero exposure is assumed for all unsampled periods, the resulting TWA is calculated per Equation 3-1a below and the industrial hygienist should document on the sampling data sheet reasons/circumstances that explain the employee's time of non-exposure (e.g., lunch break, operation completed, etc.). Where equal exposure is assumed, the resulting TWA is calculated per Equation 3-1b below and the industrial hygienist also should document the rationale on the sampling data sheet.

$$TWA\ (8\text{ - hour}) = \frac{C_1T_1 + C_2T_2 + \ldots + C_nT_n}{480\text{ minutes}}$$

Equation 3-1a

NOTE: Equation 3-1a, above, assumes that the average contaminant concentration during any unsampled portion(s) of the work shift is zero (0) and that the length of the work shift is 8 hours (i.e., 480 minutes). Field observations by the person conducting the sampling should determine if the zero exposure assumption is supportable. The denominator in Equation 3-1a must be the changed to the total minutes in the actual work shift if the work shift is other than 8 hours.

$$TWA = \frac{C_1T_1 + C_2T_2 + \ldots + C_nT_n}{T_1 + T_2 + \ldots + T_n}$$

Equation 3-1b

NOTE: Equation 3-1b, above, assumes that the contaminant concentration during any unsampled portion(s) of the work shift is equal to the average exposure for all sampled portions of the work shift. This is a conservative estimate of exposure which is biased in favor of the worker. Field observations by the person conducting the sampling should determine if this assumption is supportable.

Where:
TWA = Time-weighted average contaminant concentration
C_i = the contaminant concentration in Sample i
T_i = the duration (minutes) of Sample i

b. Non-traditional work schedules. Standards based on 8-hour exposures may not provide appropriate protection when non-traditional work schedules are used, e.g., four 10-hour days per week. Comparison of the full-shift exposure measured during a non-traditional work schedule requires that the 8-hour Navy OEL be adjusted to account for differences in the number of exposure (i.e., work) hours and recovery (i.e., non-work) hours. The following adjustments are not applicable to STEL, Ceiling, or Excursion Limit OELs.

(1) Recommended adjustments based on the Reference 3-12 model of Brief and Scala.

(a) Limitations of the model. The adjustments in Equations 3-2 and 3-3 below are based on the Brief and Scala model for unusual work shifts which is discussed in reference 3-5. This is a conservative model that accounts for both increased work shift exposures and decreased recovery time (i.e., non-occupational exposure periods). Following are some general application guidelines for the Brief and Scala model.

1. The model does not account for biological half-lives of the stressor as do the pharmacokinetic models. However, there is a general rule of thumb that PEL adjustments are not applied if the stressor half-life is less than 3 hours or greater than 400 hours. Toxicant studies show that only moderate half-life chemicals (i.e., 6-200 hours) are likely to have day-to-day accumulation during the week, even at exposures at or near the PEL.

2. The model assumes average body burden for the stressor rather than peak burden.

3. The model can be used if the PEL is based on systemic effects, regardless of whether the effects are acute or chronic.

4. Adjustments can be applied only for extended work shifts/weeks, defined as >7 hours/day or >35 hours/week. Do not use these equations for shortened work schedule adjustments (i.e., the OEL shall NEVER be adjusted upward for shortened work days or weeks). In addition, nei-

ther adjustment equation is appropriate for 24-hour (i.e., continuous) exposure.

5. Do not make PEL adjustments when the stressor is a primary irritant (i.e., PEL based on sensory irritation effects). In such cases, the stressor's action is based on "compartmental" vice whole body effects. Further, the irritation threshold is probably independent of the number of hours worked (i.e., exposed).

(b) Work weeks of less than 7 days. Equation 3-2 is used to adjust the OEL, if the work week is less than seven days.

$$\text{Adjusted OEL} = \text{OEL} \times \left(\frac{8}{h} \times \frac{24 - h}{16} \right)$$

Equation 3-2

Where: h = number of hours worked per day
8 = number of hours per traditional workday
24 = number of hours per day
16 = number of recovery hours per traditional workday

This adjusted OEL is then used for comparison with the employee's TWA exposure, and its upper or lower confidence limits as appropriate, calculated using the applicable form of Equation 3-1. Confidence limits are discussed in Chapter 4. Note that when the full shift is not sampled, you must make assumptions about the concentration during the unsampled portion of the work shift. The traditional assumptions are that the average exposure during the unsampled period are either equal to zero or equal to the average exposure during the sampled period. Any other assumptions are difficult to support and should be used rarely and with adequate documentation.

(c) 7-Day work weeks. If the non-traditional work schedule involves work on all 7 days of the week, adjust the OEL as shown in Equation 3-3:

$$\text{Adjusted } \mathbf{7-day\ work\ week}\ \text{OEL} = \text{OEL} \times \left(\frac{40}{h} \times \frac{168 - h}{128} \right)$$

Equation 3-3

Where: h = number of work (exposure) hours per 7-day work week

40 = number of work hours per traditional work week

168 = number of hours per 7-day work week (7 days x 24 hr)

128 = number of recovery (exposure-free) hours per traditional work week

(2) Adjustments mandated by OSHA in some standards (e.g., lead). Another model often used is the OSHA model, which accounts for increased work shifts only (i.e., no adjustment for decreased recovery time). The adjustments, shown in Equations 3-4 and 3-5 are based on whether the stressor acts as an acute or cumulative (chronic) hazard (OSHA has a chemical categorization table where you can look up the hazard category). The OSHA model can be used to adjust for work shifts from 15 minutes to 24 hours per day. The acute hazard equation is intended to modify the PEL to a dose no greater than that of an 8-hour exposure at the PEL. The cumulative hazard adjustment is meant to prevent excessive accumulation following many days (years) of exposure such that workers exposed more than 40 hours per week will not develop body burdens greater than those of workers in a normal 8 hour/day, 40 hour/week schedule. If a chemical is considered both an acute and a chronic hazard, calculate both adjustments and apply the more conservative PEL.

$$\text{Adjusted PEL (Acute Hazard)} = \text{PEL} \times \frac{8\,\text{hours}}{\text{Hours of Exposure per Day}}$$

Equation 3-4

$$\text{Adjsuted PEL (Cumulative Hazard)} = \text{PEL} \times \frac{40\ \text{hours}}{\text{Hours of Exposure per Week}}$$

Equation 3-5

(3) Adjustments based on other models. There are several other models, each with its own limitations and advantages. Consult Reference 3-5 for a complete discussion. Keep in mind that establishing limits for unusual workshifts is

complicated by many factors, including individual susceptibilities, stressor biological half-lives, metabolic pathways, and exposure schedules (e.g., recovery time allowances, means of elimination, consistency of exposure during extended work shift, etc.).

c. Mixtures.

(1) Additive Effects. Mixtures of stressors with ADDITIVE effects may be compared to a normalized OEL for the mixture of one (1) by calculating the concentration of each individual component of the mixture as a fraction of the OEL for that component (i.e., normalized to the OEL) and then summing these values as in Equation 3-6 below:

$$\text{Mixture summed, normalized OEL} = \frac{C_1}{OEL_1} + \frac{C_2}{OEL_2} + \ldots + \frac{C_n}{OEL_n}$$

Equation 3-6

If the “mixture summed, normalized OEL” is greater than one (1) the measured mixture level is considered to exceed the OEL for the mixture.

(2) Independent effects. If the chemical substances in the mixture have different biological actions (i.e., independent effects), the data must not be combined into a single exposure value. Instead the concentration of each chemical substance must be separately compared to its OEL.

(3) Synergistic effects. If the chemical substances in the mixture have synergistic effects, interpretation of the data should be done on a case by case basis and with great caution.

6. **SAMPLE COLLECTION AND ANALYTICAL METHODS.** All industrial hygiene samples should be collected and analyzed using methods described in Reference 3-13, the *Industrial Hygiene Sampling Guide for Consolidated Industrial Hygiene Laboratories* (NEHC Technical Manual NEHC 6290-TM96-1, September 1996).

7. **MINIMUM SAMPLE VOLUME.** The limit of quantitation of the analytical procedure establishes the minimum required volume of air for a sample. The minimum sample volume and the required sample time are computed using Equations 3-4 and 3-5:

$$\text{Minimum Sample Volume (liters)} = \frac{\text{Analytical Limit of Quantitation } (mg)}{\text{OEL } (\text{mg}/\text{m}^3) \times \text{Desired Fraction of OEL}}$$

Equation 3-7

$$\text{Required Sample Time (minutes)} = \frac{\text{Minimum Sample Volume (liters)}}{\text{Sample Flowrate (liters / minute)}}$$

Equation 3-8

NOTE: Be careful when using laboratory results that are less than the limit of detection. This is especially important when ordering an ICP (inductively coupled plasma) scan for metals, which gives results for a standard set of 14 metals. If "metal Z" was not present in the process being sampled, you cannot use the “less than” result to make ANY evaluation of exposure to "metal Z."

8. **PRE-PLANNING.** When a positive determination is made that there is potential for an employee to be exposed to a chemical, physical or biological agent at or above the action level, sampling is usually conducted to determine the extent of the exposure. Since many decisions will be based on the sampling results, it is necessary to develop a standardized sampling protocol to ensure the highest level of confidence in reported exposure levels. Careful preparation is essential to facilitate and assure the collection of valid samples. The following checks are to be made prior to field sampling:

a. All sampling equipment is to be factory and/or field calibrated in accordance with manufacturer's instructions and/or in accordance with Chapter 8 of this manual.

b. Ensure that pumps are fully charged (voltage check) and are pre-calibrated to the proper flow rates.

c. Forms for documenting air samples, bulk samples, and heat stress surveys are provided in Appendix 3-A. The associated form definitions and explanations along with personal protective equipment codes and operation codes required on some forms are also provided in Appendix 3-A.

d. Use the correct collection media as specified in Reference 3-13, the *Industrial Hygiene Sampling Guide for Consolidated Industrial Hygiene Laboratories* (NEHC Technical Manual 6290-TM96-1, September 1996). You may need to consult with the laboratory before collecting samples, particularly for unusual analytes. The laboratory may require a bulk sample or extra tubes for desorption efficiency studies.

9. **SAMPLE COLLECTION PROCEDURES.**

a. Select the employee to be sampled and discuss the purpose of the sampling strategy. Advise the employee not to remove or tamper with the sampling equipment. Inform the employee when and where the equipment will be removed.

b. Instruct the employee to notify the industrial hygienist or the supervisor should the sampling equipment require temporary removal.

c. Place the sampling equipment on the employee so that it does not interfere with work performance.

d. Attach the collection device (e.g., filter cassette, charcoal tube, etc.) to the shirt collar (i.e., within the employee's breathing zone). The inlet orifice should generally be in a downward vertical position to avoid contamination. Ensure the collection device inlet will not be covered by loose items of clothing. Position the excess tubing so as not to interfere with the work of the employee.

NOTE: For welding fume samples, place the cassette inside the welder's helmet.

e. Turn on the pump and record the time.

f. In order to determine if the desired flow rate is being maintained during sampling, the following methods should be used:

(1) A precision rotameter should be plugged into the cassette. Adjust the pump flow-rate to the desired flowrate as indicated by the precision rotameter reading.

(2) Built-in rotameters on pumps can be used for visual verification of flow rate stability during sampling. Do not use built-in rotameters for calibration purposes. As a

minimum, the flow on all pumps should be checked after the first half-hour, hour, and every 2 hours thereafter.

(3) During pump checks, check for filter loading. Particulate accumulation on the filter may affect the flow rate, especially on pumps that are not constant flow. If this occurs, replace the filter with a new one. Ensure that the collection device is still assembled properly and that the hose has not become pinched or detached from the cassette or the pump.

g. **Do not leave sampling equipment unattended**. Monitor the operation and employees throughout the workshift to ensure that sample integrity is maintained, and cyclical activities and work practices are identified. Record the time course of events, taking detailed notes concerning airborne contaminants and other conditions to assist in determining appropriate engineering controls.

h. Prepare field blank(s) during the sample period. Blanks are prepared in the same manner as the actual cassettes or tubes used for sampling, except air is not drawn through them. Blanks should also be from the same lot number as the samples. Remove both the inlet and outlet plugs from the cassette at the sampling site and immediately replace them. If using tubes, break off both ends of the blank tube at the sampling site and immediately cap.

i. For each type of sample collected, submit at least one field blank per 20 samples for OSHA sampling methods. For NIOSH sampling methods, a minimum of 2 field blanks are required for each set of samples of a specific type. If a set contains more than 20 samples, the number of field blanks required by NIOSH is 10% of the total number of samples with all fractions rounded up. NIOSH states than in no case are more than 10 field blanks required regardless of the number of samples in the set.

j. Before removing the pump at the end of the sample period, check the flow rate to ensure that the rotameter ball is still at the calibrated mark. Record the pump or precision rotameter reading.

k. Turn off the pump and record the ending time.

l. Remove the collection device from the pump. Cap tubes and impingers. For cassettes, insert cassette plugs and seal with shrink bands.

m. Prepare the samples for submission to the analytical laboratory.

n. Pumps should be post-calibrated after each day of sampling (before charging). Record the post-calibration results.

o. Activities are encouraged to develop provisions for sealing sampling media to prevent tampering and for using sample logs and chain of custody forms where such documentation is appropriate.

10. **SAMPLING PUMP CALIBRATION.**

a. If the initial (pre-) and final (post-) calibration flow rate differential is within 5%, a volume calculated using the lower flow rate should be reported to the laboratory. If the difference between the pre- and post-calibration flow rates is not within 5%, the pump may not be functioning properly. Check the battery first. If the problem is still not corrected, have the pump repaired.

NOTE: If the pump flow rate differential is greater than 5%, the sample results may still be used for exposure evaluations. The total coefficient of variation (CV_T), or overall precision (S_{rT}), of a sampling and analytical method incorporates a ±5% pump error. Depending on the CV_T or S_{rT} of the method, sampling conducted with a pump error greater than 5% may still be usable by factoring in an additional error in the CV_T or S_{rT} provided. However, the CV_T or S_{rT} should be within the required accuracy of ± 25% at the exposure limit criterion, with a confidence level of 95%.

Example: You are sampling for dichlorodifluoromethane by NIOSH method 1018. Your pump differential (i.e., pre and post calibration) is 7%. This is greater than the recommended 5%. You check the method, and find the overall precision (S_{rT}), which in the past was referred to as the total coefficient of variation (CV_T), to be 0.063. Combined with an estimate of bias (B) for the method, the accuracy of the method is calcuated to be approximately ± 12.3% (NIOSH lists the accuracy as 12.8% from the concentration range studied). Your increase of 2% pump error can be included in an adjusted S_{rT} by calculating the cumulative error as shown below:

$$\text{Adjusted } S_{rT} = \sqrt{E_1^{\,2} + E_2^{\,2}}$$

$$\text{Adjusted } S_{rT} = \sqrt{(0.063)^2 + \left(\frac{7-5}{100}\right)^2}$$

$$\text{Adjusted } S_{rT} = \sqrt{(0.063)^2 + (0.02)^2}$$

$$\text{Adjusted } S_{rT} = 0.066$$

Where: E_1 = overall method precision (S_{rT})

$$E_2 = \frac{(\text{Actual pump error in \%}) - (\text{Method's pump differential in \%})}{100}$$

The adjusted S_{rT} of 0.066 equates to about ± 13% overall accuracy for the sampling and analytical method. An explanation of how S_{rT} is used along with the method bias (B) to calculate the method accuracy is available on pages 39-43 of Reference 3-9. Since this is within the allowable ± 25%, the sample can be used to "screen" the sampled operation exposure to determine if further sampling is needed. Remember that overall precision is based on concentrations <u>at 0.1 to 2 times the exposure limit</u> (for NIOSH 1018, 495 to 9,900 mg/m^3) and the S_{rT} listed in the method may not be applicable at lower concentrations.

b. Calibration should be conducted at the same temperature and pressure as sampling.

11. **SAMPLING METHODS FOR RESPIRABLE, THORACIC, AND INHALABLE, OR “TOTAL” AEROSOLS**. Aerosol samples may represent the respirable, thoracic, or inhalable fractions of the aerosol or the nominal “total” aerosol. Each aerosol fraction requires a different sampling device. Care should be taken to determine which aerosol fraction an OEL refers to and to ensure that the correct sampling device is used.

a. <u>Respirable Aerosol Sampling</u>. Respirable dust is collected using a clean cyclone at a flow rate recommended by the cyclone manufacturer to achieve the collection efficiencies cited below. The respirable fraction of an aerosol is defined as the fraction of particles collected according to a table of collection efficiencies agreed upon by the International Organization for Standardization (ISO), the European Standardization Committee (CEN), and the American Conference of Governmental Industrial Hygienists (ACGIH). The table of collection efficiencies is published in Reference 3-6. The most often cited characteristic is the median (i.e., 50%) collection efficiency which is for particles with an aerodynamic diameter of 4 µm. Sampling is usually done with a cyclone upstream of the filter to preselect the fraction of particles of each size that pass through (i.e., penetrate) the cyclone and are collected on the filter. Several types of cyclones are available commercially the most common being the 10 mm nylon (i.e., Dorr-Oliver) cyclone and the Higgins and Dewell cyclone which evolved into the SIMPEDS cyclone. The flow rate through the cyclone is critical to obtaining the correct aerosol distribution. At present a flowrate of 1.7 L/min is used with the 10 mm nylon cyclone and a flowrate of 2.5 L/min is used with the SKC cyclone. As more cyclone performance test data becomes available flowrate recommendations change; therefore, the manufacturer should be consulted for the currently recommended flowrate to conform to the ISO/CEN/ACGIH respirable aerosol size distribution.

NOTE: When sampling for respirable dust for comparison to the ACGIH TLVs® per the International Standards Organization/ European Standardization Committee (ISO/CEN) protocol, no change is recommended for the measurement of respirable particulates using a 10 mm nylon cyclone at a flow rate of 1.7 L/min (Reference 3-1).

b. <u>Thoracic aerosol sampling</u>. Currently, there are no Navy OELs that require thoracic aerosol sampling nor are there standards or guidelines by other organizations. However, with international agreement on what this fraction is with respect to the size distribution (Reference 3-6), such OELs may soon follow. NAVENVIRHLTHCEN is aware of only one personal sampler of this type which is the GK2.69 offered by BGI Incorporated. At present, the manufacturer’s recommended flowrate for this cyclone is 1.6 L/min to collect a throacic aerosol size distribution. When such devices are used, the manufacturer should be consulted to determine the correct flowrate to collect a throacic aerosol size distribution.

c. Inhalable aerosol sampling. There are some TLVs which are set for inhalable aerosols. Two inhalable samplers are widely available in the U.S. (i.e., the Institute of Occupational Medicine [IOM] sampler distributed by SKC, Inc. and the Conical Inhalable Sampler [CIS] distributed by BGI, Incorporated). The IOM sampler operates at 2 L/min and the CIS sampler operates at 3.5 L/min. Other samplers are known to exist. As more OELs are set for ihalable aerosols, other samplers will probably be introduced. When such devices are used, the manufacturer should be consulted to determine the correct flowrate to collect an inhalable aerosol size distribution.

d. “Total” aerosol sampling. All OSHA PELs for “total” aerosols are sampled with a closed face 37 mm filter cassette. Studies have shown that this sampling method collects less aerosol than an inhalable sampler.

12. **GRAVIMETRIC ANALYSIS**. Particulates/aerosols can be collected on polyvinyl chloride (PVC) filters or matched weight mixed cellulose ester filters (MCEF) using a flow rate generally in the ranger between 1.5 and 2.5 liters per minute (L/min). Preparation and gravimetric analysis of filter samples is performed as follows:

a. Filter properties and preparation.

(1) PVC filters. Desiccate all PVC filters for at least 24 hours before pre-sample and post-sample weighing. Be sure to remove the plugs from the cassette while filters are being desiccated. PVC filters should be weighed prior to (tare weight), and after collecting the sample to arrive at the sample weight.

(2) Matched weight filters. Matched weight filters are pairs of MCEFs with weights which are matched within 100 micrograms. They are mounted one on top of the other in the same cassette. The top filter is used to collect the sample while the bottom filter acts as a reference filter which was exposed to the same environmental conditions (e.g., humidity) but has no weight gain due to capture of particulates. The difference in their weights after sampling is the sample weight. However, if the weight difference is less than 100 mircrograms, it cannot be assumed to be due to the sampling.

b. Weighing procedure. The step-by-step procedure for weighing depends on the make and model of the balance. Read the manufacturer's instruction manual for specific directions.

(1) The balance should be in a vibration-free room.

(2) Calibrate and zero the balance prior to use, after every 10 samples, and after any period it is left unattended.

(3) Using blunt-tipped forceps (i.e., do not use your fingers) remove the filter from the cassette.

(4) Immediately prior to placement on the balance, pass filter over or through an ionization unit to remove static charges. (Be sure that these ionization units are registered and handled in accordance with any radiological control program that may be applicable.)

(5) Weigh all filters at least twice.

(a) If there is more than 0.005 milligram difference in the two weighings, re-zero and recalibrate the balance.

(b) If there is less than 0.005 milligrams difference between the two weighings, average the weights for the final weight.

(6) Record and maintain all the weighing information in a filter weighing log.

(7) Include all loose material from an overloaded filter and cassette in the weighing of the filter.

NOTE: Do NOT exert downward pressure on the weighing pans. Such action can break the stirrup or damage the weighing mechanism.

13. **SAMPLING METHOD USING SORBENT TUBES.**

a. Organic vapors and gases are collected on activated charcoal, silica gel, or other adsorption tubes. Immediately before sampling, break off the ends of the adsorption tube to provide an opening approximately one-half the internal diameter of the tube. Do not use the charging inlet or the exhaust outlet of the pump to break the ends off the sorbent tubes.

b. Position the adsorption tube with the arrow in the direction of air flow, i.e., toward the sampling pump. To prevent injury to the worker, tubes should be placed in tube holders.

NOTE: If there is no arrow on the adsorption tube, insert the tube so the backup (smaller of two segments in tube) portion is closest to the pump.

c. The air to be sampled should be drawn directly into the inlet of the adsorption tube and not be passed through any hose or tubing before entering the tube. When air sampling methods require tubes in a series, as in ethylene oxide air sampling, they can be joined via the shortest practicable piece of tubing.

d. When sampling with tubes connected in a series, label each tube and any pre-filter(s) with a single sample number (i.e., your field sample number), followed by successive letters (A, B, C, etc.). For example, three tubes in series on field sample number 96-578 will be submitted to the laboratory as samples 96-578A, 96-578B and 96-578C. Since all of these tubes represent a SINGLE sample, they should be entered on a SINGLE column on the air sample form (NEHC 5100/13). Further, each tube's position in the sampling train should be noted on the sample sheet (i.e., primary (farthest from the pump) or secondary (closest to the pump).

e. Cap tubes with the supplied plastic caps immediately after sampling.

14. **SAMPLING METHOD USING MIDGET IMPINGERS/BUBBLERS.**

a. Add the specified amount of the appropriate reagent to the impinger flask either in the office or at the sampling location. If flasks containing the reagent are transported either to or from the sampling site, both the impinger stem and side arm should be sealed with caps or parafilm.

b. Collect impinger samples using a maximum flow rate of 1.0 L/min.

c. The impinger should be attached to the employee's clothing using an impinger holster. It is very important that the impinger does not tilt, causing the reagent to flow down the side arm to the hose and into the pump or to spill onto the worker's skin and clothing. Place a trap in line after the impinger to protect the pump from the absorbing solution.

d. In some instances, it will be necessary to add reagent during the sampling period to prevent the amount of reagent from dropping below one half of the original amount. Always remove the impinger from the employee before adding reagent.

e. After sampling, remove the glass stopper and stem from the impinger flask.

f. Rinse the absorbing solution adhering to the outside and inside of the stem directly into the impinger flask with a small amount (1 or 2 milliliters) of the sampling reagent. Stopper the flask tightly with the plastic cap provided or pour the contents of the flask into a 20 ml glass bottle. Rinse the flask with a small amount (1 or 2 ml) of the reagent and pour the rinse solution into the bottle. Use a Teflon® liner in the cap of the glass bottle. The cap should be taped securely in the same direction as the cap closes.

15. **SAMPLING METHODS USING DIRECT READING INSTRUMENTS.**

a. Detector tube. Detector tubes should be used primarily as a screening tool. Samples are to be taken in the breathing zone of the employee.

(1) Detector tubes may be used to determine what areas should receive full shift samples. They may also be used concurrently with full shift samples to trace sources of exposure and track variations in exposure levels throughout the work shift.

(2) Detector tubes can be used only with the pump supplied by the manufacturer, as there may be differences in flow rate between different manufacturer's pumps. Flow rate determines the adsorption rate for the chemical reactions which produce the color change or length of stain. Calibrate pumps using the method described in Chapter 8.

(3) Consult the manufacturer's instructions for information on interferences and relative standard deviations for the specific tube, as well as the number of strokes, time between strokes, time for allowing color development, and temperature, humidity and atmospheric pressure effects. Reliable readings may not be possible when interferences are present.

(a) Where there is a gradation of color change, the end point should be taken as that point where the color change can first be detected.

(b) If the indication occurs at an angle, take the reading of the longest and shortest discoloration and use the average as the end point.

(4) When interpreting the results of detector tube sampling, the largest relative standard deviation reported by the manufacturer (for the exposure range) should be applied. Where screening results may exceed the action level (after the standard deviation has been applied) then full shift sampling should be accomplished.

(5) Useful life can be adversely affected by improper care. Avoid exposing tubes to prolonged high temperatures (e.g., automobile trunks in the summertime). Refrigerated storage is recommended. Detector tubes that have exceeded their expiration date shall not be used.

(6) Consider the effects of temperature on chemical reaction speed. Tubes can be warmed in the winter by placing loose tubes in an inside pocket for approximately 15 minutes before use.

b. Direct reading gas monitors. Direct reading gas monitors, including monitors for carbon monoxide, hydrogen sulfide, combustible gases, organic vapors, and oxygen should be operated in accordance with the manufacturer's instructions. Readings should be taken as frequently as necessary to adequately characterize the exposure.

(1) Combustible gas meter.

(a) When measuring explosive levels in atmospheres where the identity of the explosive contaminant is known, use the manufacturer's response curve for that contaminant.

(b) This meter is not used to determine personal exposures to organic vapors.

(c) Each instrument approved for potentially explosive atmospheres will be labeled with the approved classes, groups and approving organization. Do not use an instrument without an approval label.

(d) Instruments are not allowed in locations where fire or explosion hazards may exist unless the instrument is certified intrinsically safe for the type (Group) of atmosphere present. When replacing batteries, use only those specified on the safety approval label.

(e) Combustible gas meters will not give reliable results in oxygen-deficient atmospheres. For this reason and other obvious safety considerations, always measure the oxygen content of the location first.

(2) Oxygen meter. Following manufacturer's guidelines, calibrate the oxygen meter in air known to contain 20.9% oxygen and outside of the space to be tested.

c. Direct reading dust monitor.

(l) Follow the manufacturer's instructions for use and calibration.

(2) Use as a screening device to estimate total or respirable dust levels.

(3) The instrument is non-specific; it measures the airborne mass concentration of dust and not specific toxic substances. Some instruments are calibrated to a specific type of dust (e.g., Arizona road dust) and may not give accurate results for dusts with different size distributions.

(4) It may give erroneous readings due to differences in collection efficiency for large particle sizes when measuring total dust.

d. Others. Other technical equipment may be used for field evaluation, such as toxic gas monitors, photoionization detectors, infrared analyzers, radiation monitors/meters, etc. All should be calibrated, maintained and operated according to the manufacturer's instructions.

16. **SAMPLING METHODS USING PASSIVE MONITORS.**

a. Instructions and limitations of the monitors are defined in the manufacturer's user’s manual and should be carefully followed.

b. As with any sampling method, an accuracy of ± 25% at the 95% confidence level within 0.5 to 2 times the PEL should be demonstrated. If this information is not available through the manufacturer, duplicate sampling can be useful in supporting the accuracy of the sampling method.

c. In high humidity environments some organic vapor monitors may experience problems due to competition of water vapor for adsorption sites on the charcoal leading to underestimation of actual concentrations.

d. Most monitors require a minimum air flowrate over the diffusion membrane to prevent creating an artificially low stressor concentration at the membrane. Therefore, many monitors may not be suitable for area sampling. Consult the manufacturer for minimum required air flowrates and suitability for use as an area monitor.

e. Care should be taken to ensure that the diffusion membranes are not torn during sampling which invalidates the sample. Since monitors are small and light-weight, they are easily turned over so that the sampling face is not exposed or may be covered by loose clothing. The industrial hygienist or technician should ensure that neither of these events occurs, otherwise the sample will be invalid.

NOTE: Passive monitors are usually designed for full-shift sampling of gases and vapors. Particulates, such as paint mist, may coat the monitor's diffusion membrane and invalidate the results.

17. **SAMPLING FOR SURFACE CONTAMINATION.**

a. General information.

(1) The terms "wipe sampling," "swipe sampling" and "smear sampling" are used synonymously to describe the techniques used for assessing surface contamination. The term "wipe sampling" will be used in this chapter.

(2) There are a variety of reasons why surface contamination, and especially removable surface contamination, may need to be assessed. Several reasons are listed below:

(a) Many toxic materials may gain entry into the body via ingestion and, in some instances, via penetration (absorption) through intact skin.

(b) Surfaces which may contact food or other materials which are ingested or placed in the mouth (e.g., chewing tobacco, gum, cigarettes) may be wipe sampled (including hands and fingers) to show contamination.

(c) Skin irritants may be evaluated for potential contact by wiping surfaces, including exposed skin (e.g., fingers, hands).

(d) Effectiveness of decontamination of surfaces and protective gear (e.g., respirators) may sometimes be evaluated by wipe sampling.

(3) There is a very strong possibility that wipe samples will give a false negative; that is, that some or all of the existing surface contamination will not be removed by a wipe sample.

(4) Available toxicological information concerning chronic skin absorption, dermatitis, etc. should be used to determine if the resulting exposure presents a potential employee hazard.

b. General technique for wipe sampling.

(1) Generally, there are two types of filters recommended for taking wipe samples:

(a) Glass fiber filters (37 mm) are usually used for materials which are analyzed by high pressure liquid chromatography (HPLC), and often for substances analyzed by gas chromatography.

(b) Paper filters are generally used for metals, and may be used for anything not analyzed by HPLC. For convenient usage, the Whatman smear tab or its equivalent is recommended.

(2) Pre-loading a group of vials with appropriate filters is a convenient method. The Whatman smear tabs should be inserted with the tab end out. Always wear clean disposable plastic gloves when handling filters. Discard gloves after each sample and don a new pair of disposable gloves for the next sample.

(3) The following procedures apply to the collection of wipe samples:

(a) At the worksite, prepare a rough sketch of the area(s) or room(s) and identify surfaces to be wipe sampled.

(b) If sampling an employee's skin or personal protective equipment, prepare/position the employee or equipment so that further contact is not needed prior to wiping. Skin wipes should not be done for materials with high skin absorption. Under no conditions should any solvent other than distilled water be used on skin or personal protective gear which directly contacts the skin.

(c) Put on a pair of clean impervious disposable gloves. A clean set of gloves should be used with each individual sample. This avoids contamination of the filter and the hand and the subsequent possibility of false positives.

(d) Withdraw the filter from the vial. If a damp wipe sample is desired, moisten the filter with the appropriate solution.

(e) Wipe approximately 100 square centimeters (cm^2) of the surface to be sampled.

> NOTE: If a template is used to outline a 100 cm^2 area, a new template should be used for each location where a sample is taken. This prevents contamination of other sample sites. Often a heavy piece of paper will suffice as a template.

(f) Without allowing the filter to contact any other surface, fold the filter with the exposed side in, then fold it over again. Place the filter in a sample vial, cap the vial, number it, and place a corresponding number at the sample location on the sketch. Include notes with the sketch giving any further description of the sample.

(g) At least one blank filter treated in the same fashion but without wiping, should be placed in a separate vial and submitted for each sampled area.

c. Special techniques for wipe sampling.

(1) Acids and bases. When examining surfaces for contamination with strong acids or bases, use pH (litmus) paper moistened with neutral distilled water (i.e., pH 7.0).

(2) Asbestos. When examining surfaces for asbestos contamination, a technique called micro-vacuuming may be used.

Micro-vacuuming only identifies presence of fibers and quantifies levels of contamination in terms of number or mass concentration. The microvacuum method has been standardized in ASTM D5755-95 and ASTM D5756-95 (References 3-10 and 3-11) which should be followed when conducting such testing. There are no regulatory standards for interpretation of microvacuum results.

(3) Lead. Wipe sampling for lead-contaminated dust should be conducted per Appendix 3-B.

(4) Polychlorinated biphenyls (PCB). PCB wipe samples should be collected following the guidance in references 3-14 and 3-15. Special preparation is required for the collection media. Contact the laboratory where the sample will be analyzed for specific requirements.

18. **REFERENCES**.

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3-2 Leidel, N. A., Busch, K. A. and Lynch, J. R.: *Occupational Exposure Sampling Strategy Manual*. DEW/NIOSH Pub. No. 77-173. Washington, D.C.: Government Printing Office. 1977.

3-3 OSHA. *Occupational Safety and Health Administration Technical Manual*, Section I, Chapter 1, Personal Sampling for Air Contaminants. OSHA Instruction TED 1.15. Washington, D.C.: U.S. Department of Labor. 1995.

3-4 AIHA: *A Strategy for Occupational Exposure Assessment,* edited by N. C. Hawkins, S. K. Norwood and J. C. Rock. Akron: AIHA, 1991.

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3-7 *Residential Lead-Based Paint Hazard Reduction Act of 1992.* Public Law 102-550, 28 October 1992.

3-8 HUD. G*uidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing*. U.S. G.P.O. No. 1995-396-057. Washington, D.C.: Government Printing Office. 1995 (Revised 1997).

3-9 NIOSH. *NIOSH Manual of Analytical Methods*, 4th Edition. DHHS (NIOSH) Publication No. 94-113. Cincinnati, OH: Government Printing Office. 1994

3-10 ASTM. *Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Concentrations*. ASTM D5755-95. West Conshohocken, PA: American Society for Testing and Materials. 1995.

3-11 ASTM. *Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Mass Concentration*. ASTM D5756-95. West Conshohocken, PA: American Society for Testing and Materials. 1995.

3-12 Brief, R. S. and Scala, R. A.: *Occupational Exposure Limits For Novel Work Schedules*. Am. Ind. Hyg. Assoc. J. 36(6):467-471

3-13 Navy Environmental Health Center. *Industrial Hygiene Sampling Guide for Consolidated Industrial Hygiene Laboratories*. NEHC Technical Manual 6290-TM96-1. 1996.

3-14 EPA. Sampling Requirements. Code of Federal Regulations, Title 40, Part 761, Section 130.

3-15 United States Environmental Protection Agency, *Field Manual for Grid Sampling of PCB Spill Sites to Verify Cleanup*. EPA-560/5-86. May 1986.

OPERATION CODES DICTIONARY

Appendix 3-A

INDUSTRIAL HYGIENE AIR SAMPLE, BULK SAMPLE AND HEAT STRESS SURVEY FORMS, DEFINITIONS, EXPLANATIONS, AND CODES

1. **FORMS**. The standard forms to be used when collecting air, wipe, or bulk samples or when conducting a heat stress survey are listed below. These forms are in Adobe Acrobat Reader PDF format and require Adobe Acrobat Reader to be installed on your computer in order to open them. To open each form, click on the blue hyperlink.

a. Industrial Hygiene Air Sample Survey Form (One Worker, Many Stressors) - NEHC Form 5100/13

b. Industrial Hygiene Single Stressor Air Sample Survey Form (Many Workers, One Stressor) - NEHC Form 5100/14

c. Industrial Hygiene Direct Reading Sample Survey Form - NEHC Form 5100/15

d. Industrial Hygiene Bulk/Wipe Sampling Form - NEHC Form 5100/16

e. Industrial Hygiene Heat Stress Survey Form - NEHC Form 5100/19 is to be used for Heat Stress Surveys Ashore.

f. Indusrial Hygiene Heat Stress Afloat Survey Form - NEHC Form 5100/20

2. **ASSOCIATED FORMS DEFINITIONS AND EXPLANATIONS**. Definitions and explanations about proper use are provided for the following forms:

a. Definitions and Explanation for NEHC Form 5100/13

b. Definitions and Explanation for NEHC Form 5100/14

3. **PERSONAL PROTECTIVE EQUIPMENT CODES**. Codes for the different types of PPE that are documented on sampling forms are provided in the linked PPECODES file.

OPERATION CODES DICTIONARY

4. **OPERATION CODES**. Codes for work operations that may result in occupational exposures and that are documented on sampling forms are provided in tabular format in the following Operation Codes Dictionary. New OPCODES are identified by a vertical line in the margin.

OPCODE	OPERATION DESCRIPTION
CLE-000-00	CLERICAL
CLE-001-00	CLERICAL, COMPUTER USE, MULTIPLE OPERATIONS
CLE-001-01	CLERICAL, COMPUTER USE, KEYBOARD AND VDT
CLE-001-99	CLERICAL, COMPUTER USE, NEC
CON-000-00	CONSTRUCTION
CON-001-00	STRUCTURE FABRICATION/REPAIR, MULTIPLE OPERATIONS
CON-001-01	STRUCTURE FABRICATION, WHARF BUILDING
CON-001-02	STRUCTURE FABRICATION, CEILING INSTALLATION/REPAI
CON-001-03	STRUCTURE FABRICATION, ROOFING INSTALLATION/REPAI
CON-001-04	STRUCTURE REPAIR, PAINT REMOVAL, SCRAPING
CON-001-05	STRUCTURE REPAIR, PAINT REMOVAL, SANDING
CON-001-06	STRUCTURE REPAIR, PAINT REMOVAL, CHEMICAL
CON-001-07	STRUCTURE REPAIR, PAINT REMOVAL, THERMAL
CON-001-08	STRUCTURE, LOCK/DOOR, REPAIR/INSTALL/MAINTAIN
CON-001-09	STRUCTURE FABRICATION, FLOOR INSTALLATION/REPAIR
CON-001-10	STRUCTURE FABRICATION/REPAIR, POWDER ACCUATED TOOL
CON-001-99	STRUCTURE FABRICATION/REPAIR, NEC
CON-002-00	ELECTRICAL INSTALLATION/REPAIR, MULTIPLE OPS
CON-002-99	ELECTRICAL INSTALLATION/REPAIR, NEC
CON-003-00	PLASTERING AND RELATED TASKS, MULTIPLE OPERATIONS
CON-003-01	DRYWALL INSTALLATION
CON-003-02	PLASTERING AND RELATED TASKS, MIX AND APPLY
CON-003-99	PLASTERING AND RELATED TASKS, NEC
CON-004-00	PLUMBING INSTALLATION/REPAIR
CON-004-01	PLUMBING INSTALLATION/REPAIR, TRANSITE WATER PIPE
CON-004-99	PLUMBING INSTALLATION/REPAIR, NEC
CON-005-00	STRUCTURE DEMOLITION, MULTIPLE OPERATIONS
CON-005-01	STRUCTURE DEMOLITION, ROOF REMOVAL
CON-005-02	STRUCTURE DEMOLITION, FLOOR TILE REMOVAL
CON-005-03	STRUCTURE DEMOLITION, SIDING REMOVAL
CON-005-04	STRUCTURE DEMOLITION, CEILING TILE REMOVAL
CON-005-05	STRUCTURE DEMOLITION, TRANSITE PANEL REMOVAL
CON-005-06	STRUCTURE DEMOLITION, MASTIC REMOVAL
CON-005-99	STRUCTURE DEMOLITION, NEC
CON-006-00	CEMENTING AND RELATED TASKS, MULTIPLE OPERATIONS
CON-006-01	CEMENTING AND RELATED TASKS, BRICK CUTTING
CON-006-02	CEMENTING AND RELATED TASKS, JACK HAMMERING

OPERATION CODES DICTIONARY

OPCODE	OPERATION DESCRIPTION
CON-006-03	CEMENTING AND RELATED TASKS, CEMENT/MORTAR MIXING
CON-006-99	CEMENTING AND RELATED TASKS, NEC
CON-007-00	EXCAVATING/GRADING, MULTIPLE OPERATIONS
CON-007-99	EXCAVATING/GRADING, NEC
CON-008-00	PAVING, MULTIPLE OPERATIONS
CON-008-99	PAVING, NEC
CON-999-99	CONSTRUCTION, NEC
IND-000-00	INDUSTRIAL
IND-001-00	METAL CLEANING MECHANICAL, MULTIPLE OPERATIONS
IND-001-01	ABRASIVE BLAST, HYDRO
IND-001-02	ABRASIVE BLAST, GLASS BEAD
IND-001-03	ABRASIVE BLAST, MINERAL GRIT
IND-001-04	ABRASIVE BLAST, SAND
IND-001-05	ABRASIVE BLAST, SHOT
IND-001-06	ABRASIVE BLAST, ORGANICS
IND-001-07	BARREL FINISHING
IND-001-08	METAL CLEANING MECHANICAL, GRINDING
IND-001-09	METAL CLEANING MECHANICAL, POLISHING AND BUFFING
IND-001-10	METAL CLEANING MECHANICAL, WIREBRUSHING
IND-001-11	METAL CLEANING MECHANICAL, SANDING
IND-001-12	METAL CLEANING MECHANICAL, NEEDLEGUNNING
IND-001-13	ABRASIVE BLAST, CLEANUP
IND-001-14	ABRASIVE BLAST, GLOVE BOX
IND-001-15	ABRASIVE BLAST, HOPPER TENDING/HELPER
IND-001-16	ABRASIVE BLAST, ALUMINUM OXIDE
IND-001-17	METAL CLEANING MECHANICAL, CHIPPING
IND-001-99	METAL CLEANING MECHANICAL, NEC
IND-002-00	CLEANING, CHEMICAL, MULTIPLE OPERATIONS
IND-002-01	ACID CLEANING, BRIGHT DIP
IND-002-02	ACID CLEANING, PICKLING
IND-002-03	ACID CLEANING, DESCALING
IND-002-04	ALKALI CLEANING, DESCALING
IND-002-05	ALKALI CLEANING, ETCHING
IND-002-06	DEGREASING, WIPE CLEANING
IND-002-07	DEGREASING, DIPPING
IND-002-08	DEGREASING, SPRAY
IND-002-09	DEGREASING, VAPOR
IND-002-10	DEGREASING, EMULSION
IND-002-11	ACID CLEANING, WIPE
IND-002-12	ACID CLEANING, SPRAY
IND-002-13	STEAM CLEANING
IND-002-14	CHEMICAL PAINT STRIPPING
IND-002-15	GAUGE CLEANING/ FLUSHING
IND-002-16	DETERGENT CLEANING, WASHING
IND-002-17	ACID CLEANING, ETCHING

OPERATION CODES DICTIONARY

OPCODE	OPERATION DESCRIPTION
IND-002-99	CLEANING, CHEMICAL, NEC
IND-003-00	METAL CLEANING, OTHER
IND-003-01	METAL CLEANING, OTHER, ULTRASONIC CLEANING
IND-003-02	METAL CLEANING, OTHER, HAND SANDING
IND-003-04	METAL CLEANING, OTHER, SCRAPING
IND-003-99	METAL CLEANING, OTHER, NEC
IND-004-00	ELECTROPLATING, MULTIPLE OPERATIONS
IND-004-01	ELECTROPLATING, SELECTIVE PLATING
IND-004-02	ELECTROPLATING, OPEN TANK
IND-004-03	ELECTROPLATING, VAPORIZATION
IND-004-99	ELECTROPLATING, NEC
IND-005-00	PAINTING, MULTIPLE OPERATIONS
IND-005-01	SPRAY PAINTING, COMPRESSED AIR
IND-005-02	SPRAY PAINTING, AIRLESS
IND-005-03	SPRAY PAINTING, ELECTROSTATIC
IND-005-04	COATING, POWDER
IND-005-05	PAINTING, BRUSH/ROLLER
IND-005-06	PAINTING, DIP
IND-005-07	SPRAY PAINTING, AEROSOL CAN
IND-005-08	PAINT MIXING/POURING
IND-005-09	SPRAY PAINTING, HIGH VOLUME LOW PRESSURE
IND-005-10	SPRAY PAINTING, AIR BRUSH
IND-005-99	PAINTING, NEC
IND-006-00	COATING OPERATIONS, MULTIPLE OPERATIONS
IND-006-01	COATING OPERATIONS, DIP
IND-006-02	COATING OPERATIONS, WIPE
IND-006-03	COATING OPERATIONS, BRUSH/ROLLER
IND-006-04	COATING OPERATIONS, SPRAY
IND-006-05	COATING OPERATIONS, TINNING
IND-006-99	COATING OPERATIONS, NEC
IND-007-00	METAL FORMING, MULTIPLE OPERATIONS
IND-007-01	METAL FORMING, FORGING
IND-007-02	METAL FORMING, EXTRUSION
IND-007-03	METAL FORMING, BENDING/FORMING
IND-007-04	METAL FORMING, SQUEEZING
IND-007-05	METAL FORMING, DRAWING
IND-007-99	METAL FORMING, NEC
IND-008-00	HEAT TREATING/HARDENING, MULTIPLE OPERATIONS
IND-008-01	HEAT TREATING/HARDENING, CARBURIZING
IND-008-02	HEAT TREATING/HARDENING, CYANIDING
IND-008-03	HEAT TREATING/HARDENING, GAS NITRIDING
IND-008-04	HEAT TREATING/HARDENING, ANNEALING
IND-008-05	HEAT TREATING/HARDENING, QUENCHING
IND-008-99	HEAT TREATING/HARDENING, NEC
IND-009-00	FOUNDRY OPERATIONS, MULTIPLE OPERATIONS
IND-009-01	MOLDING, GREEN SAND

OPERATION CODES DICTIONARY

OPCODE	OPERATION DESCRIPTION
IND-009-02	MOLDING, SHELL
IND-009-03	MOLDING, INVESTMENT CASTING
IND-009-04	MOLDING, FULL MOLD
IND-009-05	COREMAKING, SODIUM SILICATE
IND-009-06	COREMAKING, HOT BOX SYSTEM
IND-009-07	COREMAKING, NO BAKE
IND-009-08	COREMAKING, SHELL
IND-009-09	CASTING, FURNACE MELTING
IND-009-10	CASTING, OPEN HEARTH
IND-009-11	CASTING, ARC FURNACE
IND-009-12	CASTING, INDUCTION FURNACE
IND-009-13	CASTING, CRUCIBLE FURNACE
IND-009-14	CASTING, CUPOLA
IND-009-15	TRANSFER, POURING, COOLING
IND-009-16	SHAKEOUT
IND-009-17	CLEANING AND FINISHING
IND-009-18	BABBITTING
IND-009-19	SMALL MELT/POUR OPERATIONS
IND-009-99	FOUNDRY OPERATIONS, NEC
IND-010-00	METAL MACHINING, MULTIPLE OPERATIONS
IND-010-01	METAL MACHINING, CUTTING
IND-010-02	METAL MACHINING, PIERCING OR PUNCHING
IND-010-03	METAL MACHINING, SAWING
IND-010-04	METAL MACHINING, ABRASIVE GRINDING
IND-010-05	METAL MACHINING, DRILLING AND BORING
IND-010-06	METAL MACHINING, MILLING
IND-010-07	METAL MACHINING, TURNING
IND-010-08	METAL MACHINING, SHAPING AND SLOTTING
IND-010-09	METAL RIVETING
IND-010-99	METAL MACHINING, NEC
IND-011-00	WELDING, MULTIPLE OPERATIONS
IND-011-01	WELDING, RESISTANCE
IND-011-03	WELDING, OXYFUEL
IND-011-04	WELDING, SOLID STATE
IND-011-05	WELDING, BRAZING
IND-011-06	WELDING, LASER
IND-011-07	WELDING, ELECTRON BEAM
IND-011-08	WELDING, SHIELDED METAL ARC
IND-011-09	WELDING, GAS METAL ARC
IND-011-10	WELDING, GAS TUNGSTEN ARC
IND-011-11	WELDING, PLASMA ARC
IND-011-12	WELDING, AIR CARBON ARC
IND-011-13	ELECTRICAL SOLDERING
IND-011-14	TORCH SOLDERING
IND-011-15	FLUX CORE PROCESSES
IND-011-16	HOT WORK HELPER/FIREWATCH

OPERATION CODES DICTIONARY

OPCODE	OPERATION DESCRIPTION
IND-011-17	WELDING, STUD
IND-011-18	WELDING, SPOT
IND-011-19	SOLDERING, HEATED IRON
IND-011-99	WELDING, NEC
IND-012-00	THERMAL SPRAYING, MULTIPLE OPERATIONS
IND-012-01	ELECTRIC ARC SPRAYING
IND-012-02	FLAME SPRAYING
IND-012-03	PLASMA SPRAYING
IND-012-04	HIGH VELOCITY OXYFUEL (HVOF) SPRAYING
IND-012-99	THERMAL SPRAYING, NEC
IND-013-00	CUTTING, MULTIPLE OPERATIONS
IND-013-01	THERMAL CUTTING
IND-013-02	OXYGEN CUTTING
IND-013-03	ARC CUTTING
IND-013-04	ELECTRON BEAM CUTTING
IND-013-05	LASER CUTTING
IND-013-06	AIR CARBON ARC CUTTING
IND-013-07	PLASMA CUTTING
IND-013-99	CUTTING, NEC
IND-014-00	NON-DESTRUCTIVE TEST, MULTIPLE OPERATIONS
IND-014-01	NON-DESTRUCTIVE TEST, VISUAL
IND-014-02	NON-DESTRUCTIVE TEST, MAGNETIC PARTICLE TEST
IND-014-03	NON-DESTRUCTIVE TEST, LIQUID PENETRANT TEST
IND-014-04	NON-DESTRUCTIVE TEST, ULTRASONIC TEST
IND-014-05	NON-DESTRUCTIVE TEST, ACOUSTICAL EMISSION TEST
IND-014-06	NON-DESTRUCTIVE TEST, RADIOGRAPHIC TEST
IND-014-07	NON-DESTRUCTIVE TEST, LASER INSPECTION
IND-014-08	NON-DESTRUCTIVE TEST, WEIGHT TEST
IND-014-09	NON-DESTRUCTIVE TEST, ACID SPOT TESTING
IND-014-99	NON-DESTRUCTIVE TEST, NEC
IND-015-00	PLASTICS/RUBBER PROCESSING, MULTIPLE OPERATIONS
IND-015-01	PLASTICS/RUBBER POTTING
IND-015-02	PLASTICS/RUBBER DEPOTTING
IND-015-03	PLASTICS/RUBBER MOLDING
IND-015-04	PLASTICS/RUBBER FOAMING
IND-015-05	PLASTICS/RUBBER GRINDING
IND-015-06	PLASTICS/RUBBER CUTTING
IND-015-07	PLASTICS/RUBBER DRILLING
IND-015-08	PLASTICS/RUBBER GLUING
IND-015-09	PLASTICS/RUBBER MIXING
IND-015-10	HELMET POUR
IND-015-11	PLAQUE POUR
IND-015-12	PLASTICS/RUBBER SANDING
IND-015-13	PLASTICS/RUBBER POLISHING AND BUFFING
IND-015-14	PLASTICS/RUBBER HEAT SEALING
IND-015-15	PLASTICS/RUBBER MILLING/MACHINING

OPERATION CODES DICTIONARY

OPCODE	OPERATION DESCRIPTION
IND-015-99	PLASTICS/RUBBER PROCESSING, NEC
IND-016-00	FIBER REINFORCED COMPOSITE, MULTIPLE OPERATIONS
IND-016-01	FIBER REINFORCED COMPOSITE, LAYUP, HAND
IND-016-02	FIBER REINFORCED COMPOSITE, LAYUP, SPRAY
IND-016-03	FIBER REINFORCED COMPOSITE, GRINDING/SANDING
IND-016-04	FIBER REINFORCED COMPOSITE, CUTTING
IND-016-05	FIBER REINFORCED COMPOSITE, DRILLING
IND-016-06	FIBER REINFORCED COMPOSITE, REMOVE PAINT, SAND
IND-016-07	FIBER REINFORCED COMPOSITE, REMOVE PAINT NEEDLEGUN
IND-016-08	FIBER REINFORCED COMPOSITE, REMOVE PAINT, GRIND
IND-016-09	FIBER REINFORCED COMPOSITE, REMOVE PAINT, BLAST
IND-016-10	FIBER REINFORCED COMPOSITE, MIXING
IND-016-99	FIBER REINFORCED COMPOSITE, NEC
IND-017-00	INSULATION, ASBESTOS, MULTIPLE OPERATIONS
IND-017-01	ASBESTOS, INSTALLATION
IND-017-02	ASBESTOS, CLASS I, NPE REMOVAL
IND-017-03	ASBESTOS, FABRICATION
IND-017-04	ASBESTOS, NON-CONTAINMENT REMOVAL
IND-017-05	ASBESTOS, CLASS I, MULTIPLE GLOVE BAG REMOVAL
IND-017-06	ASBESTOS, GASKET WORK
IND-017-07	ASBESTOS, AMBIENT SAMPLING
IND-017-08	ASBESTOS, ENCAPSULATION
IND-017-09	ASBESTOS, CLASS I, MINI-ENCLOSURE REMOVAL
IND-017-10	ASBESTOS, CLASS III, MINI-ENCLOSURE REMOVAL
IND-017-11	ASBESTOS, CLASS III, SINGLE GLOVE BAG REMOVAL
IND-017-12	ASBESTOS, MECHANICAL LOADER BAGGING
IND-017-13	ASBESTOS, HEPA VACUUM MAINTENANCE
IND-017-14	ASBESTOS, CLASS I, GLOVEBOX REMOVAL
IND-017-15	ASBESTOS, CLASS I, WATERSPRAY REMOVAL
IND-017-17	ASBESTOS, FLOOR CARE/MAINTENANCE
IND-017-18	ASBESTOS, PACKING MATERIAL WORK
IND-017-99	INSULATION, ASBESTOS, NEC
IND-018-00	INSULATION, MAN MADE FIBERS, MULTIPLE OPERATIONS
IND-018-01	INSULATION, MAN MADE FIBERS, INSTALLATION
IND-018-02	INSULATION, MAN MADE FIBERS, REMOVAL
IND-018-03	INSULATION, MAN MADE FIBERS, FABRICATION
IND-018-99	INSULATION, MAN MADE FIBERS, NEC
IND-019-00	INSULATION, OTHER, MULTIPLE OPERATIONS
IND-019-01	INSULATION, OTHER, INSTALLATION
IND-019-02	INSULATION, OTHER, REMOVAL
IND-019-03	INSULATION, OTHER, FABRICATION
IND-019-99	INSULATION, OTHER, NEC
IND-020-00	WOODWORKING, MULTIPLE OPERATIONS
IND-020-01	WOODWORKING, CUTTING
IND-020-02	WOODWORKING, JOINTING
IND-020-03	WOODWORKING, DRILLING

OPERATION CODES DICTIONARY

OPCODE	OPERATION DESCRIPTION
IND-020-04	WOODWORKING, MORTISING/ROUTING
IND-020-05	WOODWORKING, TURNING LATHES
IND-020-06	WOODWORKING, SANDING, DRUM
IND-020-07	WORDWORKING, SANDING, DISK
IND-020-08	WOODWORKING, SANDING, BELT
IND-020-09	WOODWORKING, SANDING, HAND
IND-020-10	WOODWORKING, PRESERVATIVE APPLICATION
IND-020-11	WOODWORKING, GLUING
IND-020-12	WOODWORKING, STAINING
IND-020-13	WOODWORKING, TRANSPARENT FINISHES
IND-020-14	WOODWORKING, DUST COLLECTOR CLEANING
IND-020-99	WOODWORKING, NEC
IND-021-00	STONE, MINERAL HANDLING, MULTIPLE OPERATIONS
IND-021-01	STONE, MINERAL HANDLING, INSTALLATION
IND-021-02	STONE, MINERAL HANDLING, REMOVAL
IND-021-03	STONE, MINERAL HANDLING, CUTTING
IND-021-04	STONE, MINERAL HANDLING, DRILLING
IND-021-99	STONE, MINERAL HANDLING, NEC
IND-022-00	ELECTRONICS REPAIR, MULTIPLE OPERATIONS
IND-022-01	ELECTRONICS REPAIR, INSTALLATION/REPAIR
IND-022-02	ELECTRONICS REPAIR, CALIBRATION, MANOMETRIC
IND-022-03	ELECTRONICS REPAIR, CALIBRATION, RFR EQUIPMENT
IND-022-04	ELECTRONICS REPAIR/MAINT, OPERATE EQUIPMENT
IND-022-99	ELECTRONICS REPAIR, NEC
IND-023-00	EQUIPMENT REPAIR, MULTIPLE OPERATIONS
IND-023-01	EQUIPMENT REPAIR, HYDRAULICS
IND-023-02	EQUIPMENT REPAIR, GENERATOR
IND-023-03	EQUIPMENT REPAIR, AIRCRAFT ENGINE TESTING
IND-023-04	EQUIPMENT REPAIR, MECHANICAL ASSEMBLY/REPAIR
IND-023-05	EQUIPMENT REPAIR, ENGINE ACCESSORY TESTING
IND-023-06	EQUIPMENT REPAIR, BRAKE/GEARBOX REPAIR
IND-023-07	EQUIPMENT REPAIR, FUEL ACCESSORY TESTING
IND-023-08	EQUIPMENT REPAIR, ELECTRICAL
IND-023-09	EQUIPMENT REPAIR, ENGINE TEST
IND-023-10	EQUIPMENT REPAIR, AIRCRAFT ENGINE PRESERVATION
IND-023-11	EQUIPMENT REPAIR, ORDNANCE TESTING
IND-023-13	EQUIPMENT REPAIR, SEALANT/ADHESIVE WORK
IND-023-14	EQUIPMENT REPAIR, BODY WORK
IND-023-15	EQUIPMENT REPAIR, NON-ASBESTOS GASKET WORK
IND-023-16	EQUIPMENT REPAIR, PMS/LUBRICATE
IND-023-17	EQUIPMENT REPAIR/MAINT/TEST, GAUGE CALIBRATION
IND-023-18	PULL/INSTALL ELECTRICAL CABLE
IND-023-19	EQUIPMENT INSTALLATION/REMOVAL
IND-023-20	EQUIPMENT REPAIR/MAINT/TEST, TIRE AND WHEEL
IND-023-99	EQUIPMENT REPAIR, NEC
IND-024-00	CHEMICAL PROCESSING, MULTIPLE OPERATIONS

OPERATION CODES DICTIONARY

OPCODE	OPERATION DESCRIPTION
IND-024-01	CHEMICAL PROCESSING, ADD/MIX X-RAY DEVELOPER
IND-024-02	CHEMICAL PROCESSING, X-RAY DEVELOPING
IND-024-03	CHEMICAL PROCESSING, CHANGE PROCESS CHEMICALS
IND-024-99	CHEMICAL PROCESSING, NEC
IND-025-00	HM/HW HANDLING/CLEANUP, MULTIPLE OPERATIONS
IND-025-01	HM/HW HANDLING/CLEANUP, BALLAST INSTALLATION
IND-025-02	HM/HW HANDLING/CLEANUP, BALLAST REMOVAL
IND-025-03	HM/HW HANDLING/CLEANUP, ASBESTOS
IND-025-04	HM/HW HANDLING/CLEANUP, PCBs
IND-025-05	HM/HW HANDLING CLEANUP, FILTER MAINTENANCE
IND-025-06	HM/HW HANDLING CLEANUP, LEAD SHIELDING
IND-025-07	HM/HW HANDLING CLEANUP, SOLVENT/METAL RECLAMATION
IND-025-08	HM/HW HANDLING CLEANUP, CONTAINER CRUSH/PUNCTURE
IND-025-09	HM/HW HANDLING CLEANUP, FLUORESCENT TUBE CRUSHING
IND-025-10	HM/HW HANDLING CLEANUP, CONTAINER SAMPLE/OPEN
IND-025-11	HM/HW HANDLING CLEANUP, POURING
IND-025-12	HM/HW HANDLING CLEANUP, ISSUE/RECEIVE
IND-025-13	HM/HW HANDLING CLEANUP, SPILL RESPONSE
IND-025-14	HM/HW HANDLING CLEANUP, MIXED WASTE OPERATIONS
IND-025-15	HM/HW HANDLING CLEANUP, TANK CLEANING/FLUSHING
IND-025-16	HM/HW HANDLING CLEANUP, AEROSOL CAN PUNCTURING
IND-025-99	HM/HW HANDLING/CLEANUP, NEC
IND-026-00	EXPLOSIVE PRODUCTION, MULTIPLE OPERATIONS
IND-026-01	EXPLOSIVE PRODUCTION, PREMIX OPERATIONS
IND-026-02	EXPLOSIVE PRODUCTION, MIXING AND POURING
IND-026-03	EXPLOSIVE PRODUCTION, CLEANING MIXING EQUIPMENT
IND-026-04	EXPLOSIVE PRODUCTION, TESTING
IND-026-05	EXPLOSIVE PRODUCTION, DETONATION
IND-026-99	EXPLOSIVE PRODUCTION, NEC
IND-027-00	QUALITY ASSURANCE LAB, MULTIPLE OPERATIONS
IND-027-01	QUALITY ASSURANCE LAB, FUEL TESTING
IND-027-02	QUALITY ASSURANCE LAB, PATCH TESTING
IND-027-99	QUALITY ASSURANCE LAB, NEC
IND-028-00	HYPERBARIC ATMOSPHERES, MULTIPLE OPERATIONS
IND-028-01	HYPERBARIC ATMOSPHERES, SONAR DOME WORK
IND-028-99	HYPERBARIC ATMOSPHERES, NEC
IND-029-00	ELECTRICAL, MULTIPLE OPERATIONS
IND-029-01	ELECTRICAL, BATTERY CHARGING
IND-029-02	ELECTRICAL, MOTOR REWIND, VARNISH DIP
IND-029-03	ELECTRICAL, MOTOR REWIND, BAKE-OUT
IND-029-99	ELECTRICAL, NEC
MED-001-00	MEDICAL, MULTIPLE OPERATIONS
MED-001-01	MEDICAL, ETO STERILIZATION
MED-001-02	MEDICAL, ANESTHETIC ADMINISTRATION
MED-001-03	MEDICAL, ANATOMICAL SPECIMEN PRESERVATION

OPERATION CODES DICTIONARY

OPCODE	OPERATION DESCRIPTION
MED-001-04	MEDICAL, TISSUE/ORGAN GROSSING
MED-001-05	MEDICAL, CAST CUTTING
MED-001-06	MEDICAL, CORRECTIVE LENS MANUFACTURE
MED-001-07	MEDICAL, X-RAY DEVELOPMENT
MED-001-08	MEDICAL, CHEMICAL STERILIZATION, NEC
MED-001-99	MEDICAL, NEC
MED-002-00	DENTAL, MULTIPLE OPERATIONS
MED-002-01	DENTAL, FILLING/DRILLING
MED-002-02	DENTAL, PROSTHETICS
MED-002-03	DENTAL, ETO STERILIZATION
MED-002-04	DENTAL, ANESTHETIC ADMINISTRATION
MED-002-05	DENTAL, X-RAY DEVELOPMENT
MED-002-99	DENTAL, NEC
MIL-000-00	MILITARY SPECIFIC OPERATIONS
MIL-001-00	WEAPONS HANDLING, MULTIPLE OPERATIONS
MIL-001-01	RANGE CLEANING
MIL-001-02	WEAPONS FIRING
MIL-001-03	RANGE SUPERVISION
MIL-001-04	PIT CLEANUP
MIL-001-05	TORPEDO FUELING/DEFUELING
MIL-001-06	TORPEDO DISASSEMBLY
MIL-001-07	WEAPONS CLEANING/PMS
MIL-001-08	BREECHING
MIL-001-99	WEAPONS HANDLING, NEC
MIL-002-00	FLIGHT LINE OPERATIONS, MULTIPLE OPERATIONS
MIL-002-01	FLIGHT LINE OPERATIONS, LINE TROUBLE SHOOTING
MIL-002-02	FLIGHT LINE OPERATIONS, AIRCRAFT LOADING
MIL-002-03	FLIGHT LINE OPERATIONS, LAUNCH AND RECOVERY
MIL-002-04	FLIGHT LINE OPERATIONS, FUEL/DEFUEL AIRCRAFT
MIL-002-05	FLIGHT LINE OPERATIONS, LIQUID OXYGEN HANDLING
MIL-002-06	FLIGHT LINE OPERATIONS, AIRCRAFT CLEANING
MIL-002-07	FLIGHT LINE OPERATIONS, OPERATE SUPPORT EQUIPMENT
MIL-002-08	FLIGHT LINE OPERATIONS, MK 105 SLED OPERATION
MIL-002-99	FLIGHT LINE OPERATIONS, NEC
MIL-003-00	SHIPBOARD PROCESSES, MULTIPLE OPERATIONS
MIL-003-01	SHIPBOARD PROCESSES, WATCHSTANDING, BRIDGE
MIL-003-02	SHIPBOARD PROCESSES, WATCHSTANDING, FLIGHT DECK
MIL-003-03	SHIPBOARD PROCESSES, WATCHSTANDING, ENGINEERING
MIL-003-04	SHIPBOARD PROCESSES, WATCHSTANDING, OTHER
MIL-003-05	SHIPBOARD PROCESSES, DRILLS, BECCE
MIL-003-06	SHIPBOARD PROCESSES, DRILLS, GENERAL QUARTERS
MIL-003-07	SHIPBOARD PROCESSES, ATMOSPHERE EQUIPMENT MAINT
MIL-003-08	SHIPBOARD PROCESSES, FUELING/DEFUELING
MIL-003-09	SHIPBOARD PROCESSES, LINE HANDLING
MIL-003-10	SHIPBOARD PROCESSES, WELL DECK OPERATIONS

OPERATION CODES DICTIONARY

OPCODE	OPERATION DESCRIPTION
MIL-003-99	SHIPBOARD PROCESSES, NEC
MIL-004-00	PREVENTIVE MAINTENANCE SYSTEM, MULTIPLE OPERATIONS
MIL-004-01	PREVENTIVE MAINTENANCE SYSTEM, DAMAGE CONTROL
MIL-004-02	PREVENTIVE MAINTENANCE SYSTEM, FILTER CLEANING
MIL-004-99	PREVENTIVE MAINTENANCE SYSTEM, NEC
MIS-000-00	MISCELLANEOUS, MULTIPLE OPERATIONS
MIS-000-01	EQUIPMENT MONITORING
MIS-000-02	MACHINE SEWING
MIS-000-03	LAUNDRY/DRY CLEANING OPERATIONS
MIS-000-99	MISCELLANEOUS OPERATIONS, NEC
PRO-000-00	PROFESSIONAL,TECH AND MGMT
PRO-001-00	PROFESSIONAL AND TECHNICAL, MULTIPLE OPERATIONS
PRO-001-01	LABORATORY CHEMICAL ANALYSIS
PRO-001-02	MUSICAL PERFORMANCE
PRO-001-03	COMPUTER OPERATIONS
PRO-001-04	ASBESTOS INSPECTION AND BULK SAMPLING
PRO-001-05	ASBESTOS INSPECTION
PRO-001-06	FIBER COUNTING/IDENTIFICATION
PRO-001-07	WORKPLACE MONITORING/MEASUREMENTS
PRO-001-08	WORKSITE/EQUIPEMNT INSPECTIONS
PRO-001-99	PROFESSIONAL/TECHNICAL, NEC
PRO-002-00	MANAGEMENT, MULTIPLE OPERATIONS
PRO-002-01	SUPERVISION
PRO-002-99	MANAGEMENT, NEC
RND-000-00	RESEARCH AND DEVELOPMENT
RND-000-99	RESEARCH AND DEVELOPMENT, NEC
SER-000-00	SERVICE
SER-001-00	TRANSPORTATION, MULTIPLE OPERATIONS
SER-001-01	TRANSPORTATION, TRUCK OPERATION
SER-001-02	TRANSPORTATION, TRAIN OPERATION
SER-001-03	TRANSPORTATION, TRACTOR TRAILER OPERATION
SER-001-04	TRANSPORTATION, SMALL WATERCRAFT OPERATIONS
SER-001-05	TRANSPORTATION, RAILROAD TRACK MAINTENANCE
SER-001-06	TRANSPORTATION, FUELING/DEFUELING
SER-001-99	TRANSPORTATION, NEC
SER-002-00	MOTOR VEHICLE MAINTENANCE, MULTIPLE OPERATIONS
SER-002-01	MOTOR VEHICLE MAINTENANCE, TESTING
SER-002-02	MOTOR VEHICLE REPAIR/OVERHAUL
SER-002-03	MOTOR VEHICLE MAINTENANCE, BRAKE WORK
SER-002-04	MOTOR VEHICLE MAINTENANCE, CLUTCH WORK
SER-002-05	MOTOR VEHICLE MAINTENANCE, BODY WORK
SER-002-99	MOTOR VEHICLE MAINTENANCE, NEC

OPERATION CODES DICTIONARY

OPCODE	OPERATION DESCRIPTION
SER-003-00	PEST CONTROL, MULTIPLE OPERATIONS
SER-003-01	PEST CONTROL, MIXING
SER-003-02	PEST CONTROL, PUMP SPRAY
SER-003-03	PEST CONTROL, FOGGING
SER-003-04	PEST CONTROL, FUMIGATION
SER-003-05	PEST CONTROL, AEROSOL CAN SPRAY
SER-003-06	PEST CONTROL, POWDER APPLICATION
SER-003-99	PEST CONTROL, NEC
SER-004-00	BUILDING MAINTENANCE, MULTIPLE OPERATIONS
SER-004-01	BUILDING MAINTENANCE, SWEEPING
SER-004-02	BUILDING MAINTENANCE, AC/R CHARGING
SER-004-03	BUILDING MAINTENANCE, CRAWL SPACE/ATTIC
SER-004-04	BUILDING MAINTENANCE, CLASS IV ASBESTOS
SER-004-05	BUILDING MAINTENANCE, CLEAN VENTILATION SYSTEMS
SER-004-99	BUILDING MAINTENANCE, NEC
SER-005-00	GROUNDS MAINTENANCE, MULTIPLE OPERATIONS
SER-005-01	GROUNDS MAINTENANCE, STREET SWEEPING
SER-005-02	GROUNDS MAINTENANCE, LAWN MAINTENANCE
SER-005-03	GROUNDS MAINTENANCE, TRASH COMPACTING
SER-005-99	GROUNDS MAINTENANCE, NEC
SER-006-00	PROTECTIVE SERVICES, FIRE, MULTIPLE OPERATIONS
SER-006-01	PROTECTIVE SERVICES, FIRE, TRAINING
SER-006-99	PROTECTIVE SERVICES, FIRE, NEC
SER-007-00	PROTECTIVE SERVICES, SECURITY, MULTIPLE OPERATION
SER-007-01	FIRING RANGE CLEANING
SER-007-02	WEAPONS FIRING
SER-007-03	FIRING RANGE SUPERVISION
SER-007-04	FIRING RANGE PIT CLEANING
SER-007-05	WEAPONS CLEANING
SER-007-06	DOCUMENT SHREDDING
SER-007-07	PROTECTIVE SERVICES, GUARD OPERATIONS
SER-007-99	PROTECTIVE SERVICES, SECURITY, NEC
SER-008-00	GRAPHIC ARTS, MULTIPLE OPERATIONS
SER-008-01	GRAPHIC ARTS, SILK SCREENING
SER-008-02	GRAPHIC ARTS, PHOTOGRAPHY DEVELOPING
SER-008-03	GRAPHIC ARTS, PHOTOGRAPHY CHEMICAL MIXING
SER-008-04	GRAPHIC ARTS, PHOTOGRAPHY EQUIPMENT CLEANING
SER-008-99	GRAPHIC ARTS, NEC
SER-009-00	RECREATION
SER-010-00	PRODUCTION/DIST. OF UTILITIES, MULTIPLE OPERATION
SER-010-01	COMPRESSED AIR BREATHING
SER-010-02	BOILER CLEANING
SER-010-03	BOILER REPAIR
SER-010-04	EQUIPMENT MONITORING
SER-010-05	TRANSFORMER REPAIR/MAINTENANCE
SER-010-06	SHIP/SHORE CONNECTION

OPERATION CODES DICTIONARY

OPCODE	OPERATION DESCRIPTION
SER-010-07	ESP MAINTENANCE/CLEANING
SER-010-08	STEAM PIT MAINTENANCE
SER-010-99	PRODUCTION/DIST. OF UTITLITIES, NEC
SER-011-00	SUPPLY AND MATERIALS HANDLING, MULTIPLE OPERATION
SER-011-01	FOAM IN PLACE PACKAGING
SER-011-02	MATERIAL HANDLING EQUIPMENT OPERATION
SER-011-03	TOOL AND PARTS ISSUE
SER-011-04	CRANE OPERATION
SER-011-05	PACKAGING
SER-011-06	SUPPLY AND MATERIALS HANDLING, RIGGING
SER-011-99	SUPPLY AND MATERIALS HANDLING, NEC
SER-012-00	PRINTING/REPRODUCTION, MULTIPLE OPERATIONS
SER-012-01	PRINTING/REPRODUCTION, DIAZO PRINTING
SER-012-02	PRINTING/REPRODUCTION, DOCUMENT PREPARATION
SER-012-03	PRINTING/REPRODUCTION EQUIPMENT CLEANING
SER-012-04	PRINTING/REPRODUCTION, OFFSET PRINTING
SER-012-05	PRINTING/REPRODUCTION, ENGRAVING
SER-012-99	PRINTING/REPRODUCTION, NEC
SER-013-00	COMMUNICATIONS, MULTIPLE OPERATIONS
SER-013-01	COMMUNICATIONS, TELETYPE OPERATION
SER-013-02	COMMUNICATIONS, EQUIPMENT OPERATION
SER-013-99	COMMUNICATIONS, NEC
SER-014-00	FOOD SERVICE, MULTIPLE OPS
SER-014-01	FOOD SERVICE, SCULLERY WORK
SER-014-02	FOOD SERVICE, OVEN CLEANING
SER-014-99	FOOD SERVICE, NEC
SER-015-00	HW/SEWER TREATMENT, MULTIPLE OPERATIONS
SER-015-99	HW/SEWER TREATMENT, NEC
SER-016-00	WATER TREATMENT, MULTIPLE OPERATIONS
SER-016-01	WATER TREATMENT, CHLORINATION/BROMINATION
SER-016-99	WATER TREATMENT, NEC
SER-017-00	LAUNDRY SERVICES, MULTIPLE OPERATIONS
SER-017-01	LAUNDRY SERVICES, DRY CLEANING
SER-017-02	LAUNDRY SERVICES, DRY CLEANER MAINTENANCE
SER-017-03	LAUNDRY SERVICES, WASHER/DRYER/PRESS OPERATION
SER-017-99	LAUNDRY SERVICES, NEC
SER-018-00	BARBERING/COSMETOLOGY, MULTIPLE OPERATIONS
SER-018-01	BARBERING/COSMETOLOGY, CUTTING HAIR
SER-018-01	BARBERING/COSMETOLOGY, NEC
SER-999-99	SERVICE, NEC

NOTE: New OPCODES are marked in the left margin.

Appendix 3-B

WIPE SAMPLING FOR SETTLED LEAD-CONTAMINATED DUST

1. **INTRODUCTION**. Wipe samples for settled leaded dust can be collected from floors (both carpeted and uncarpeted), interior and sash/sill contact areas, and other reasonably smooth surfaces. Wherever possible, hard surfaces should be sampled. Wipe media should be sufficiently durable so that it is not easily torn, but can be easily digested in the laboratory. Recovery rates of between 80-120% of the true value should be obtained for all media used for wipe sampling. Blank media should contain no more than 25 µg/wipe. **Contact the laboratory for specific instructions.**

2. **WIPE SAMPLING MATERIALS AND SUPPLIES**. The following equipment and supplies must be used for sampling:

a. Any wipe material that meets the following criteria may be used:

(1) Contains low background lead levels (less than 5 µg/wipe)

(2) Is a single thickness

(3) Is durable and does not tear easily (do not use Whatman™ filters)

(4) Does not contain aloe

(5) Can be digested in the laboratory

(6) Has been shown to yield 80-120% recovery rates from samples spiked with leaded dust (not lead in solution)

(7) Must remain moist during the wipe sampling process (wipes containing alcohol may be used as long as they do not dry out)

b. Non-sterilized, non-powdered disposable gloves are required to prevent cross-sample contamination from hands.

c. Wipes are placed in non-sterilized polyethylene centrifuge tubes (50 ml size) or an equivalent hard-shell container that can be rinsed quantitatively in the laboratory.

d. Dust sample collection forms.

e. Camera and film or video camera and tape to document exact locations (Optional)

f. Marking the area to be wiped can be done in either of the following ways:

(1) Masking tape. Masking tape is used on-site to define the area to be wiped. Masking tape is required when wiping window sills and window wells in order to avoid contact with window jambs and channel edges. Masking tape on floors is used to outline the exact area to be wiped.

(2) Hard, smooth, reusable templates made of laminated paper, metal, or plastic. Note: Periodic wipe samples should be taken from the templates to determine if the template is contaminated. Disposable templates are also permitted so long as they are not used for more than a single surface. Templates should be larger than 0.1 ft^2, but smaller than 2 ft^2. Templates for floors are typically 1 ft^2. Templates are usually not used for windows due to the variability in size and shape (use masking tape instead).

g. Sample container labels or permanent marker

h. Trash bag or other waste receptacle (Do not use pockets or trash containers at the residence.)

i. Rack, bag, or box to carry tubes (optional)

j. Measuring tape

k. Disposable shoe coverings (optional)

2. <u>**SINGLE SURFACE WIPE SAMPLING PROCEDURE**</u>

a. <u>Outlining the Wipe Area</u>.

(1) Floors: Identify the area to be wiped. Do not walk on or touch the surface to be sampled (the wipe area). Apply adhesive tape to perimeter of the wipe area to form a square or rectangle of about one square foot. No measurement

is required at this time. The tape should be positioned in a straight line and corners should be nominally perpendicular. When putting down any template, do not touch the interior wipe area.

(2) Window sills and other rectangular surfaces: Identify the area to be wiped. Do not touch the wipe area. Apply two strips of adhesive tape across the sill to define a wipe area at least 0.1 square foot in size (approximately 4 inches x 4 inches). When using tape, do not cross the boundary tape or floor markings, but be sure to wipe the entire sampling area. It is permissible to touch the tape with the wipe, but not the surface beyond the tape.

b. Preliminary inspection of the wipes. Inspect the wipes to determine if they are moist. If they have dried out, do not use them. When using a container that dispenses wipes through a "pop-up" lid, the first wipe in the dispenser at the beginning of the day should be thrown away. The first wipe may be contaminated by the lid and is likely to have dried to some extent. Rotate the container before starting to ensure liquid inside the container contacts the wipes.

c. Preparation of centrifuge tubes. Examine the centrifuge tubes and make sure that the tubes match the tubes containing the blind spiked wipe samples. Partially unscrew the cap on the centrifuge tube to be sure that it can be opened. Do not use plastic baggies to transport or temporarily hold wipe samples. The laboratory cannot measure lead left on the interior surface of the baggie.

d. Gloves. Don a disposable glove on one hand; use a new glove for each sample collected. If two hands are necessary to handle the sample, use two new gloves, one for each hand. It is not necessary to wipe the gloved hand before sampling. Use a new glove for each sample collected.

e. Wiping surfaces that are approximately square.

(1) Initial placement of wipe: Place the wipe at one corner of the surface to be wiped with wipe fully opened and flat on the surface.

(2) First wipe pass (i.e., side-to-side): With the fingers together, grasp the wipe between the thumb and the palm. Press down firmly, but not excessively with both the palm and fingers (do not use the heel of the hand). Do not touch the surface with the thumb. If the wipe area is a

square, proceed to wipe side-to-side with as many "S"-like motions as are necessary to completely cover the entire wipe area. (See step f below for non-square areas.) Exerting excessive pressure on the wipe will cause it to curl. Exerting too little pressure will result in poor collection of dust. Do not use only the fingertips to hold down the wipe, because there will not be complete contact with the surface and some dust may be missed. Attempt to remove all visible dust from the wipe area.

(3) Second wipe pass (i.e., top-to-bottom): Fold the wipe in half with the contaminated side facing inward. (The wipe can be straightened out by laying it on the wipe area, contaminated side up, and folding it over.) Once folded, place in the top corner of the wipe area and press down firmly with the palm and fingers. Repeat wiping the area with "S"-like motions, but on the second pass, move in a top-to-bottom direction. Attempt to remove all visible dust. Do not touch the contaminated side of the wipe with the hand or fingers. Do not shake the wipe in an attempt to straighten it out, since dust may be lost during shaking.

f. Wiping Rectangular areas (e.g., window sills). If the surface is a rectangle (such as a window sill), two side-to-side passes must be made over half of this surface, the second pass with the wipe folded so that the contaminated side faces inward. For a window sill, do not attempt to wipe the irregular edges presented by the contour of the window channel. Avoid touching other portions of the window with the wipe. If there are paint chips or gross debris in the window sill, attempt to include as much of it as possible on the wipe. If all of the material cannot be picked up with one wipe, field personnel may use a second wipe at their discretion and insert it in the same container. Consult with the analytical laboratory to determine if they can perform analysis of two wipes as a single sample. When performing single-surface sampling, do not use more than two single surface wipes for each container. If heavily dust-laden, a smaller area should be wiped. It is not necessary to wipe the entire window well but do not wipe less than 0.1 ft^2 (approximately 4 inches x 4 inches).

g. Packaging the Wipe. After wiping, fold the wipe with the contaminated side facing inward again, and insert aseptically (without touching anything else) into the centrifuge tube or other hard-shelled container. If gross debris is present, such as paint chips in a window well, make every attempt to include as much of the debris as possible in the wipe.

h. Labeling the Centrifuge tube. Seal the tube and label with the appropriate identifier. Record the laboratory submittal sample number on the field sampling form.

i. Measuring the Area to be sampled. After sampling, measure the surface area wiped to the nearest eighth of an inch using a tape measure or a ruler. The size of the area wiped should be at least 0.1 ft^2 in order to obtain an adequate limit of quantitation (25 µg/wipe is the typical detection limit with flame AA. No more than 2 square feet should be wiped with the same wipe or else the wipe may fall apart. Record specific measurements for each area wiped on the field sampling form.

j. Documenting the Sample. Fill out the appropriate field sampling forms completely. Collect and maintain any field notes regarding type of wipe used, lot number, collection protocol, etc.

k. Disposing of Trash. After sampling, remove the masking tape and throw it away in a trash bag. Remove the glove; put all contaminated gloves and sampling debris used for the sampling period into a trash bag. Remove the trash bag when leaving the structure.

3. **COMPOSITE WIPE SAMPLING**. Whenever composite sampling is contemplated, consult with the analytical laboratory to determine if the laboratory is capable of analyzing composite samples. When conducting composite wipe sampling, the procedure stated above should be used with the following modifications: When outlining the wipe areas, set up all of the areas to be wiped before sampling. The size of these areas should be roughly equivalent, so that one room is not over-sampled. After preparing the centrifuge tube, put on the glove(s) and complete the wiping procedures for all subsamples. A separate wipe must be used for each area sampled. After wiping each area, carefully insert the wipe sample into the same centrifuge tube (no more than 4 wipes per tube). Once all subsamples are in the tube, label the tube. Record a separate measurement for each area that is subsampled on the field collection form. Finally, complete trash disposal, making sure that no masking tape is left behind. Risk assessors and inspector technicians do not have to remove their gloves between subsample wipes for the same composite

sample as long as their gloved hands do not touch an area outside of the wipe areas. If a glove is contaminated, the glove should be immediately replaced with a clean glove. In addition to these procedural modifications, the following rules for compositing should be observed:

a. Different types of surfaces. Separate composite samples are required from carpeted and hard surfaces (*e.g.*, a single composite sample should not be collected from both carpeted and bare floors).

b. Different types of components. Separate composite samples are required from each different component sampled (*e.g.*, a composite sample should not be collected from both floors and window sills).

4. **BLANK PREPARATION**. After sampling the final space of the day, but before decontamination, field blank samples should be obtained. Analysis of the field blank samples determines if the sample media is contaminated. Each field blank should be labeled with a unique identifier similar to the others so that the laboratory does not know which sample is the blank (i.e., the laboratory should be "blind" to the blank sample). Blank wipes are collected by removing a wipe from the container with a new glove, shaking the wipe open, refolding as it occurs during the actual sampling procedure, and then inserting it into the centrifuge tube without touching any surface or other object. One blank wipe is collected for structure/space sampled or, if more than one structure/space is sampled per day, one blank for every 50 field samples, whichever is less. Also, collect one blank for every lot used. Record the lot number.

5. **INSPECTOR DECONTAMINATION**. After sampling, wash hands thoroughly with plenty of soap and water before getting into a car. A bathroom in the dwelling unit may be used for this purpose, with the owner’s or resident’s permission. If there is no running water at the sampling site, use wet wipes to clean the hands. During sampling, inspectors must not eat, drink, smoke, or otherwise cause hand-to-mouth contact.

6. **QUALITY ASSURANCE/QUALITY CONTROL**. If more than 50 µg/wipe is detected in a blank sample, the samples should be collected again since the media is contaminated. Blank correction of wipe samples is not recommended.

NOTE: For surface contamination evaluations (clearance and/or risk assessments) regarding lead-based paint activities defined by the Residential Lead-Based Paint Hazard Reduction Act of 1992, consult the protocol in the Housing and Urban Development "Guidelines" (reference 3-8), 40 CFR 745.227, and local regulatory requirements.